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AUTHOR Norwood, Frank W.
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ABSTRACT

To provide a baseline for thinking about future experiments, this paper begins with a review of educational satellite experiments undertaken in the past. A review and analysis of the communications satellites currently in use by both the National Aeronautics and Space Administration and by the various commercial carriers is presented in non-technical terms. In each case, there is a brief description of the technological parameters of the system and a description of the kinds of services which the hardware can provide. In forecasting the "second generation" of satellites, the paper limits itself to plans and proposals which are now under discussion and avoids unrealistic speculation, an approach which, in a field under rapid development, may be as much a limit as a strength. (Author/VT)

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COMMUNICATIONS SATELLITE SERVICES IN THE UNITED STATES--

Present Status, Future Prospects

A Paper Prepared for the

National Institute of Education

Frank W. Norwood

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Abstract:

The development of communications satellites dates from efforts undertaken by the National Aeronautics and Space Administration in the early 1960's. In 1969, NASA announced a new policy under which access to its experimental satellites is rrovided without charge to educators and others who wish to conduct communications experiments in their own disciplines. The Department of Health, Education and Welfare has been the principal sources of funds for some--but by no means all--of the non-technical experiments which have been undertaken, and the National Institute of Education has provided the financial support of the major educational experiments which have been done.

In 1974, the first domestic commercial communications satellite service became available. There are now three "domsat" systems in operation and the Federal Communications Commission has recently granted permission for a fourth, which is unlikely to be in operation much before the end of the decade. New "second generation" satellite systems for the 1980's and beyond are already under discussion and in the planning stage, including both experimental and commercial systems.

Those who plan--and those who plan to fund--communications

satellite experiments need to know about the opportunities offered by presently available satellites, both those available without cost from NASA and those commercially available from the satellite common carriers. If their planning is to take more than a short-sighted view, they should also know--to the extent that can now be predicted--what future satellites will offer. To provide such information in terms comprehensible to the non-engineer is the purpose of this paper.

Statement of Objectives:

This paper seeks to present, in non-technical terms, a review and analysis of the communications satellites currently in use by both the National Aeronautics and Space Administration and by the various commercial carriers.

In each case, it provides a brief description of the technological parameters of the system and a description of the kinds of services which the hardware can provide.

In forecasting the "second generation" of satellites, the paper limits itself to plans and proposals which are now under discussion and eschews "blue sky" speculation, an approach which, in a field under rapid development, may be as much a limit as a strength. This paper, however, is neither by nor for space scientists whose qualifications might permit them such speculation.

To provide a baseline for thinking about future experiments, the paper begins with a review of educational satellite experiments undertaken in the past

Introduction:

NIE was the principal source of financial support for the educational experiments carried on in Alaska, Appalachia, and the Rocky Mountain States via the National Aeronautics and Space Administration's Applications Technology Satellite Six (ATS-6) in 1974-75. Now, after the year-long Satellite Instructional Television Experiment (SITE) in India, ATS-6 is once again available for experimentation in the U.S. and the Pacific Basin. Earlier NASA satellites, ATS-1 and ATS-3 are also available, as is the U.S.-Canadian joint venture, CTS, the Communications Technology Satellite.

Experiments undertaken on NASA satellites must take place within the bounds of certain constraints:

- Since these satellites are experimental, the useful lifetime of each can only be estimated. Except for ATS-1 and ATS-3, which are technically similar, no "backup" service is available in the event of spacecraft failure.

- The mandate of the National Aeronautics and Space Administration precludes providing any operational (i.e., regular, on-going) service. Consequently, NASA cannot accept proposals for experiments of more than one year's duration--although subsequent proposals for follow-on experiments, based upon experience gained during the initial year, are often accepted.

- Currently available experimental spacecraft are unique satellites, operating at frequencies and at power levels different from present domestic commercial communications satellites.

Neither the National Institute of Education, nor potential users are likely to find much interest in "dead end" experiments which, while they may establish the efficacy of using an experimental satellite, have no way of translating experiment results into operational benefits via regularly available space technology. While some successful experiments might "go operational" by terrestrial means, prudent forward planning requires some understanding of the current state of the art of satellite and earth station technology, the service offerings of commercial satellite operators, and the probable developments of the near-term future.

Communications Satellite Technology:

Science fiction writer Arthur C. Clark first proposed in an article in a 1945 issue of Wireless World a system of three man-made satellites which would orbit the earth at 22,300 miles above the equator. At that altitude, a satellite is geosynchronous; that is to say its period of rotation around the earth exactly matches the twenty-four hours which the planet takes to revolve on its axis. If the satellite is placed in the equatorial plane, it will also be geostationary; from the earth below it will appear to remain stationary in space. Since such a satellite can "see" some 42% of the earth below, three such geostationary satellites are sufficient to establish a global communications system, accessible from any spot in the world except the extreme polar regions.

In less than twenty years, the writer's dream became the scientists' reality. In 1962, Telstar was launched. It contained an active electronic device powered by solar batteries. Called a "transponder," this device can receive a television signal from earth, amplify it, and retransmit it to a receiving station a continent away. But Telstar was a low-orbit, not a geosynchronous, satellite. Its weak transponder required large and very expensive earth stations which had to track the satellite as it appeared to move across the sky. And, because the satellite

was not geostationary, it was only useful during those periods when it was visable from both Europe and the United States.

In 1963-64, NASA launched Syncom II and III, the first successful geosynchronous communications satellites, and thus established the technological basis for all future communications satellites. (The single exception is the Soviet Union's Orbita series of Molniya satellites which use an elliptical polar orbit to relay telephone and television to the entire USSR, including Siberia's northern latitudes.)

Since Syncom II and III, the development of communications satellites has been a tale of increasingly greater satellite size and available power. By and large, in both international and domestic satellites, these developments have been used to provide more transponders and thus increase the number of television channels or telephone messages which the satellite can carry. Intelsat I ("Early Bird"), launched in 1965, had but a single transponder, capable of one TV signal or 240 two-way voice channels. RCA's Satcom I and II, launched in 1975-76, are each capable of 24 television channels or 14,000 two-way voice circuits through their 24 transponders.

This increase in satellite capacity has been a major

factor in the continually decreasing cost of satellite services. To some degree, the savings have been passed along to the user, but the relationship is not linear. Transmission of a telephone message or a television program between two cities involves, not only the satellite link, but terrestrial components, as well. The signal must be fed from its point of origination by microwave or land line to the satellite earth station, located in an exurban environment free from electronic interference. At the other end of the journey the signal must be relayed by terrestrial means from the receiving earth station to its final destination. Since the cost of these "end loops" is uneffected by increasing satellite efficiency, user cost reductions do not fall proportionally with space segment costs.

Using improvements in satellite technology to gain more transponders per satellite makes economic and technical sense for common carrier systems designed to carry heavy traffic loads among a relatively limited number of earth stations. Such communications satellites are termed "'fixed service' satellites" because they are analogous to terrestrial "fixed service" microwave systems which service the same purpose. There is, however, another way to invest the benefits of our ability to launch larger satellites and achieve greater on-board power than could be accomplished a decade ago.

Instead of increasing the number of 5-watt transponders, the technology can also produce satellites with a smaller number of more powerful transponders. Such a trade-off permits the development of satellite systems in which earth station size, complexity, and cost can be substantially reduced. Further, because high power systems must operate in a less crowded portion of the frequency spectrum, receiving stations (and, often, transmitting facilities) need not be located in non-urban "quiet zones," but may often be placed at the point of use, thus eliminating the added cost of end-loops.

For systems serving only a few hundred--or even a few thousand--earth stations, such systems architecture may not be appropriate, but for systems employing "'broadcasting service' satellites" and designed to serve tens of thousands or hundreds of thousands of receivers, the "big satellite: small earth station" configuration is the clear economic and technical choice.

While no broadcast satellites yet exist in commercial service, the technology has already been developed and demonstrated and it is principally NASA's experimental broadcast satellites, ATS-6 and CTS, which have been the vehicles for the experiments in health, education and other social services undertaken to date.

Educational Experiments on NASA Satellites:

In the summer of 1969, the National Aeronautics and Space Administration announced a policy under which educational institutions, corporations, government agencies and other profit and nonprofit organizations might propose experiments to be undertaken on NASA satellites. Proposals are received and reviewed by the space agency, and those that are accepted may use the satellite without charge. In addition, NASA provides associated space system support, including access to NASA's established earth stations. Users, in turn, are required to develop detailed experiment and evaluation plans, and to find funding needed for such new earth stations as the experiment may require, for software, and for experiment administration and operations.

At the time of the 1969 announcement, the available satellites were ATS-1 and ATS-3. Launched in 1966 and 1967, these satellites were originally designed to perform a variety of scientific and communications experiments. The technology which attracted most interest from education and health experimenters had originally been incorporated in the spacecrafts for aircraft-to-ground communications during transoceanic flight. These VHF transponders cannot transmit con-

ventional television, but their narrow-band capabilities are sufficient for teletype, data or voice communications. With appropriate terminal gear, ATS-1 and -3's VHF transponders could handle facsimile or slow-scan television, as well. Both satellites have wide area coverage, including the coterminus United States, Alaska and Hawaii.

A major advantage, in addition to the wide coverage afforded by these satellites, is the fact that the VHF transponders can be accessed by simple earth stations based upon modified taxicab radios. All operating stations are, in effect, on a giant party line. By tying the two satellites together via a relay in Denver, one experimenter established regular discussions among education professionals from Fiji, New Zealand, Hawaii and other Pacific locations, several Alaska bush communities, rural Appalachia, and Washington, D.C.

While the ATS-1 and ATS-3 experiments have underscored the fact that television is not always required for important educational and social gains, it should be pointed out that these NASA satellites are experimental, and they cannot be taken as models for future operational systems. For one thing, the VHF frequencies used by ATS-1 and -3 are not

available for operational service. Secondly, operating these satellites in the VHF mode puts all of the available power of a multi-million dollar satellite into a single narrow-band communications channel; any future operational system will necessarily require more complex and more costly earth stations.

Experiments conducted in ATS-1 and/or -3 include: National Public Radio's program relays to KUAC (FM) at the University of Alaska; delivery of educational radio programs directly to rural Alaskan schools; PEACESAT ("Pan-Pacific Education and Communications Experiments by Satellite"), a "party line" network which, since 1971, has linked about a dozen earth stations in Hawaii, New Zealand and small island nations in the Pacific. The National Education Association has conducted its experiments on ATS-1 and -3, utilizing not only the PEACE-SAT stations, but those in Alaska and Appalachia as well, moderating its international teachers' meetings from Green-belt or Bethesda, Md., in suburban Washington. Among the best known applications of the ATS-1 and -3 VHF transponders has been their use use in connection with the experiments conducted on ATS-6.

ATS-6 was, at the time of its launch in 1974, the most powerful communications satellite extant. A large and very expensive spacecraft, only a small portion of its multi-million dollar costs are associated with its communications experiments, and only a portion of those with the health and education telecommunications experiments carried on in the United States. In 1969, a Memorandum of Understanding between the National Aeronautics and Space Administration and the Indian Space Research Organization was signed looking toward a major demonstration in India of the use of satellite television for educational and developmental purposes. ATS-6's most prominent feature, its 30' diameter space-deployed antenna, was specifically designed to concentrate a frequency modulated UHF television signal in a footprint which could cover the Indian subcontinent. (The less-than-optimum size and shape of the 2.5 GHz footprint in the U.S. was a function of focusing the 2.5 GHz transmissions via an antenna designed for a different frequency.)

The Indian Satellite Instructional Television Experiment (SITE) could take place at UHF because that band is not in use in India for terrestrial TV broadcasting, as it is in the United States and in Europe. While the possibility of of future ATS-6 experiments at UHF in the Pacific and the Caribbean is under consideration, the use of this transmitter

in the continental United States is infeasible.

The U.S. experiments on ATS-6 made use of two transponders operating at 2.5 GHz (the familiar 2500 MHz band of the terrestrial Instructional Television Fixed Service). After the announcement of the NASA-ISRO Memorandum of Understanding in 1969, U.S. educational interests, recognizing that no such experiments could take place within the United States without a new and appropriate frequency allocation, persuaded the Federal Communications Commission and the Department of State to modify the draft proposals for the forthcoming 1971 World Administrative Radio Conference, called by the International Telecommunications Union, and to seek an international frequency allocation in the 2.5 GHz band. At the 1971 meeting in Geneva, the U.S. proposal was accepted, and the ITU allocated the bard 2.5-2.69 GHz for satellite broadcasting for education and development, not only in the U.S., but on a worldwide basis.

ATS-6's two 2.5 GHz ("S-band") transponders deliver a nominal 15 watts output, three times the output power of conventional commercial satellites. The effective power is further increased by the action of the 30' diameter antenna, which focuses the two beams into footprints which, together, measured approximately 300 by 500 miles for the 1974 experiments. (The size and shape of the footprints is, of course, influenced

by the orbital location of the satellite and the location of the terrestrial area to be illuminated.)

In the Rocky Mountain States, the Satellite Technology Demonstration was undertaken by the Federation of Rocky Mountain States. Television programs were relayed by ATS-6 from Denver to more than fifty rural communities, and were made available to others in the Rocky Mountain west through retransmission of the satellite programs by local public television stations. The experiment's primary target audience was junior high school students in the 56 participating communities. In addition, an in-service education course for teachers and administrators, and an adult education series on regional problems were offered. A "Materials Distribution Service" project used the satellite to provide overnight delivery of films and tapes requested by individual schools and teachers.

On the East Coast, the Appalachian Educational Satellite Project was organized and directed by the Appalachian Regional Commission. In preparation, ARC surveyed 32,000 public school teachers and found that their most pressing felt needs included in-service education in the teaching of reading and in career education. The University of Kentucky organized and administered

the courses which were transmitted by ATS-6 to fifteen Regional Educational Service Agencies. Fifteen colleges within the region participated in offering graduate credit for the courses. Dr. Harold E. Morse, ARC's Director of Education and head of the AESP, notes that the most significant break-through accomplished by the AESP may be, not the use of technology per se, but its role as a catalyst in establishing appropriate cooperative arrangements involving fifteen institutions of higher education, thirteen state departments of education, and a large number of local school districts spread over a multi-state area.

In Alaska, yet another set of educational experiments was conducted on ATS-6. Eighteen earth stations were employed, including two which could transmit television at S-band, as well as receive. (See discussion of earth stations, infra.) The four-and-a-half hour weekly TV schedule included two instructional series for elementary school pupils, a teacher education series, and a propram for adults, "Alaska Native Magazine."

In each of these experiments in the Rockies, Appalachia and Alaska, three types of earth stations were employed. Receive-only earth stations used a 10' parabolic antenna with an associated electronics package for frequency and modulation conversion, translating the satellite 2.5 GHz FM television

signal to a conventional signal and channel acceptable to an ordinary television set. Simple to operate, the earth stations' only controls were an on-off switch, a pilot light, and a signal strength meter. Their cost in a quantity of 150 was less than $5000 each, installed. So-called "intensive terminals" consisted of the same recieve only ("RO") gear, plus a narrow-band two-way earth station for ATS-1. These installations cost approximately $8000.

While ATS-6 was designed to both transmit and receive video and audio signals at S-band, problems of frequency clearance prevented the use of S-band up-links except in Alaska. Instead, ATS-1 was employed as a means of relaying interactive voice and data, a compromise which would not have been necessary if ATS-6's uplink S-band frequencies had been different. Any future experimental or operational satellite system at S-band need not be faced with such problems, and would not need to employ a second satellite for talk-back purposes.

In Alaska it was possible to use S-band for both up- and down-links. There, "comprehensive terminals" could be used. Transmitting as well as receiving TV from ATS-6, their cost (with accompanying VHF earth stations for ATS-1) was approximately $55,000.

The newest available experimental communications satellite is a joint U.S.-Canadian venture, the Communications Technology Satellite (CTS). Like ATS-6, it is designed to explore the technological configuration of a high power satellite working into small and relatively inexpensive ground stations. While ATS-6 operates in the 2.5 GHz S-band with 15 watts per channel, CTS is pioneering the newly-available 12 GHz K-band with two transponders, one of 20 watts, and the other having a power of 200 watts. CTS's greater power and optimized antenna design make possible greatly increased coverage; each of CTS's two independently-steerable antennas can cover about one-third of the U.S. or Canada.

Not all of the comparisons, however, are in CTS's favor. The need for more sophisticated electronics at these higher frequencies has its impact on earth station costs. Further, heavy rainfall, which has little effect on satellite signals at 2.5 GHz, can provide serious degradation at 12 GHz. In consequence, at K-band it is necessary to design the system with additional signal strength for "rain margin," to overcome potential adverse weather conditions.

Television receive-only earth stations can be had at $11-13,000 in small quantities; video RO with narrowband return at something under $20,000. A "Class I" station, which

can transmit and receive a video signal of high quality is priced at about $162,000. (A savings of as much as $50,000 might be realized if the terminal were bought in an unassembled state.)

One point worth noting: Unlike the VHF earth stations for ATS-1 and -3, or the S-band stations for ATS-6, the CTS earth stations might later be used with some future commercial satellite. The 12 GHz band is the next frontier for communications satellites. Satellite Business Systems has recently received a Federal Communications Commission go-ahead to construct a system at these frequencies and, in Canada, Telesat, the Canadian domestic satellite entity, plans some K-band transponders on its next satellite.

The Domestic Satellites:

At present, there are three operating commercial domestic satellite systems serving the United States: those of Western Union, RCA American Communications, and Comsat General (a subsidiary of the Communications Satellite Corporation.) Each of these systems has certain similarities:

- Each is a fixed service satellite system, operating

in the crowded C-band (4 and 6 GHz) spectrum.

- Each satellite has multiple transponders of limited (5 watt) power.

- Relatively large earth stations (15-33 foot antenna) are required to receive television.

- Each system has both in-orbit and on-ground spare satellites to provide full redundancy and fully "backed-up" service.

- Each system includes company-owned earth stations from which customers may access the satellites.

- Each system is capable of providing service to any or all fifty states.

But each domestic satellite system is also different from the others in several important respects. A description of each system follows.

Western Union's satellite system consists of a space segment comprised of two satellites, Westar I and II, in geo-stationary orbit at 99° and 123.5° West. Westar III is a spare, ready to be launched in the event of the failure of one of the operating satellites, or when traffic grows sufficiently to warrant a third satellite in the system. The satellites are Hughes-built spin-stabilized HS-350's whose solar cells develop 300 watts of prime power, driving twelve transponders, each of which can carry a color TV signal (with associated audio), some 7000 two-way telephone conversations, 24,000 teletypewriter circuits, or high speed data. The design life of the Westar satellites is seven years, and Western Union plans its next generation of satellites to include, inter alia, C-band transponders which can continue the service now provided by Westar I and II. Since Westar I, the first U.S. domestic satellite, was launched in 1974, the half-way point in its design life is fast approaching.

The existing terrestrial segment includes WU-owned-and-operated earth stations in exurban locations near New York, San Francisco, Los Angeles, Chicago, Dallas and Atlanta. Other WU-owned earth stations are planned, and several Westar users operate, or plan to operate, their own ground facilities.

Western Union offers both end-to-end service in which WU

earth stations are used, and also leases full or partial transponders to users who prefer to transmit to and/or receive from the Westar satellites by use of their own earth stations. A principal Westar customer is the Fairchild-owned American Satellite Corp., which leases three channels on Westar I and maintains its own network of earth stations to serve such customers as the Department of Defense and the Wall Street Journal.

Of particular interest to potential satellite experimenters in the public service areas is the fact that public broadcasting has contracted with Western Union to lease three (later, four) transponders on Westar 1. Initial plans call for replacing the present telephone company supplied terrestrial interconnection for public television, with interconnection for the affiliates of National Public Radio to be added at an as yet undetermined future date. When the television interconnection is fully operational in 1979, some 147 earth stations, owned not by Western Union, the Corporation for Public Broadcasting nor the Public Broadcasting Service but by the broadcasting station licensees, themselves, will be in place in all fifty states, Puerto Rico and the Virgin Islands. In addition to these receive-only earth stations, a master up-link station in the Virginia suburbs of Washington will feed programming from the headquarters of the Public Broadcasting System, and five other up-links will be established at locations yet to be determined but to

be chosen so as to provide program origination capacity for public television's regional networks.

Despite the fact that the satellite interconnection system will give public television four times as much network capacity as is currently available with the terrestrial network, CPB president Loomis sees little prospect of unused time which might be made available to other non-profit groups, "except at four o'clock in the morning." It is agreed, however, that achieving the widest possible use of the public broadcasting interconnection is a highly desirable goal.

If there is no time to be had on the satellite transponders, what is there to be shared? The answer comes in two parts: First, the four transponders which public broadcasting will lease on Westar I are only one-third the number the satellite offers. "Satellite time" may be had from the satellite's owner, Western Union, on a yearly, daily, hourly or "special event" basis at common carrier rates. Sharing of public broadcasting's earth stations, both for transmission and reception, is a genuine possibility, and an attractive prospect, although again there are important facts to be kept in mind.

Access to these earth stations will have to be negotiated, not with Western Union, CPB or PBS, but with their licensees, the local public television stations and, in the case of the regional up-links, the regional networks. While it is anticipated that most PTV station

managements and boards will be favorably inclined toward sharing, some may find themselves bound by local institutional constraints. Second, since most public television stations will be equipped to receive, at any one time, only two of the satellite's transponders, and since those receivers will be in use for public television's own purposes, additional electronic hardware will be required at each earth station.

As a percentage of the total cost of each earth station, approximately $150,000, the new equipment represents a cost increase of less than ten per cent. But to a user who needs to reach a substantial number of points, an investment of $8500-10,000 would quickly mount up. The hardware costs to add a third satellite receiver to each public television ground station in the system would be on the order of $1.25 million.

Clearly, such a figure is not so formidable if the needs of a substantial number of potential users can be aggregated and the resulting network, built upon the much larger investment made by public broadcasting, would appear a rare bargain. Public broadcasting has expressed a willingness to enter into a continuing dialogue with all groups in the non-profit public interest sector, and the Public Service Satellite Consortium and the Public Interest Satellite Association are concerned with developing the necessary process of

market aggregation.

In addition to the economic questions which are raised by the concept of sharing the public broadcasting satellite interconnection, there are regulatory questions to which the answers are by no means clear. Will the Federal Communications Commission permit system sharing? by whom? and under what circumstances? Will entities other than public broadcasters be permitted to lease transponder time at the favorable rates available to public broadcasting under Section 396(h) of the Communications Act which specifies that nothing in the Act shall pervent common carriers from providing service to public broadcasting at free or reduced rates?

Western Union has already indicated that it will, in time, seek FCC permission to negotiate access to public broadcasting earth stations. CPB has agreed to support such a plea because its overall agreement with the carrier specifies that, if FCC permission is granted, some of the monies paid by Western Union for use of the earth stations will be applied against WU's charges to public broadcasting, thus reducing the operating costs of the public broadcasting interconnection system.

When such permission is sought by Western Union, the Commission will most assuredly receive objections from other parties who believe

that such permission should be denied. They will argue that such a move would give Western Union a unique and unfair advantage in the satellite business, allowing it to offer commercial services with greater flexibility and lessend dependence upon costly terrestrial end loops, and all by "piggy-backing" on a very substantial $26 million investment of public funds for public television earth stations. Since these stations will be aimed at Westar I and at no other satellite, commercial or noncommercial, there is no way in which any competing carrier can capitalize on this opportunity.

The question of access to public broadcasting earth stations by nonprofit users is somewhat less complicated because such issues of competitive commercial advantage do not arise. Nonetheless, any sharing will raise new issues which the Commission will have to decide, and, FCC proceedures being what they are, the Commission will not make any such decissions until specific proposals are brought to it by interested parties. That could well mean that the question of Western Union access will be disposed of before the issues of access by noncommercial interests are even raised.

Last July, the Federal Communications Commission issued two rulings which may--or, indeed, may not--be useful in forecasting the prospects for sharing by noncommercial entities. In its final

decision in Docket No. 20097, it gave the users of private line services the right to engage in unlimited sharing so long as service is not offered to other users at a profit. Costs of systems management and scheduling have to be apportioned among users by a nonprofit entity. Later the same month, the FCC handed down another decision, this one having to do with the cost-shared use of satellite earth stations by cable television operators. Several cable TV operators who own their own earth stations to receive pay TV programming had asked the Commission whether they could serve neighboring independent CATV systems and split expenses with them. The Commission ruled that "bona fide non-profit cost-sharing arrangements" are consistent with the FCC's domestic communications satellite policies.

While plans for the satellite interconnection system for public television are well defined, the details of a similar satellite interconnection for public radio are not yet known. To be served are the "CPB qualified" stations which are members of National Public Radio. Currently, NPR service is delivered to most of its affiliates by leased telephone lines with limited frequency response. Most music programs, and all stereo music, must go to the stations by tape sent through the mails. The satellite interconnection will overcome these limitations by providing four simultaneous high quality 15KHz audio channels. The channels can be used to provide a choice of four simultaneous monophonic programs, two stereo transmissions or a single quadraphonic program.

Planning for satellite interconnection for public radio is running about one year behind that for public television. While the target date for the first satellite service to an initial group of twenty-four PTV stations is early 1978 and for all PTV stations to have satellite service by the end of that year, public radio will not likely have its satellite interconnection in operation until 1979. The issues of system sharing which pertain to television will also impact the radio interconnection and its possible availability to other users, noncommercial or commercial.

The RCA Satcom system is owned and operated by RCA American Communications (known as "RCA Americom") and RCA Alaska Communications (RCA Alascom). The satellites are in orbit at 119°W (Satcom I), and 135°W (Satcom II). As with the Westar system, there is an on-ground spare, ready to be launched as a back-up satellite in the case of a massive failure of either of the on-orbit birds, or at a later date when traffic growth required more space capacity.

Physically, the RCA-built satellites are somewhat larger than the Hughes-built Westars and have twenty-four, rather than twelve, transponders. This is accomplished by a scheme of frequency reuse in which the available band is used for two sets of twelve channels, each set being offset in center frequency from the other much as bricks are on a wall. Further to reduce interference, the transmissions

are are polarized orthogonally (i.e., at right angles to each other). Coverage of the forty-eight contiguous states, Alaska, and Hawaii are provided, although only twelve of the twenty-four channels of each satellite are available to Hawaii, and at a somewhat lower power. The design life is eight years.

In the lower forty-eight states, RCA Americom owns and operates ground stations between New York and Philadelphia, near Chicago, Atlanta, Houston, San Francisco and Los Angeles. These can send and receive video, audio, data, etc. among those points or to Alaska and to receive-only stations anywhere within Satcom coverage. Other RCA-owned stations are planned for Seattle, Denver, Washington and Honolulu. In Alaska, RCA Alascom installations serve Anchorage, Fairbanks and Juneau, and a growing number of bush communities are equipped with small stations for two-way telephonic conversation. In twenty-three bush communities, TV can be received, with the State of Alaska providing, under tarrif, a daily schedule of commercial network, PBS and local Alaska-produced programming. Plans are to expand this service eventually to 100 Alaska villages.

Like Western Union, RCA offers a variety of service configurations, including end-to-end service, lease of full or partial transponders, and the lease of dedicated earth stations. At present, one of RCA's

major customers is Home Box Office, Inc., the pay television by cable subsidiary of Time-Life, Inc. Earth stations for the reception of HBO programming are owned by a growing number of cable TV systems, including such multiple system operators as Teleprompter and UA Columbia as well as by independent CATV systems. As noted above, actions taken by the FCC last year make it possible for several cable systems to join together to share use and costs of such earth stations. In October, 1976, the number of cable TV earth stations receiving Satcom signals had passed ninety and the growth continues to develop rapidly.

In a somewhat parallel development, two broadcasters have entered into agreements by which their programs are relayed on RCA Satcom transponders to cable systems, and at least in the case of one, to other television broadcasting stations. The Christian Broadcasting Network is a religious group headquartered in Tidewater Virginia where elaborate television production facilities are maintained for such programs as "The 700 Club." An RCA Satcom relay brings such programs to other CBN-owned TV stations, to independent stations, commercial or noncommercial, which carry CBN shows, and to cable television systems.

The other broadcaster currently using RCA Satcom is Turner Communications whose channel 17 station in Atlanta features a heavy sports schedule which is being marketed to cable systems

across the country. A spin-off company, Southern Satellite Systems acts as a sales agent for the programming, sale of small earth stations, and, if plans mature, supporting the use of some of the cable industry's receive-only capability for such other applications as de-centralized business meetings and conventions.

According to RCA executives, prices for various hardware and services are currently at or near the following figures: Purchase of a dedicated earth station capable of video reception and duplex wideband data service or twelve voice grade circuits, $550,000, insatlled. The same facilities could be leased at approximately $22,000 per month. A receive-only station with a 10 meter (33') antenna would cost about $75,000, and could be leased on an annual basis at $1800/mo. or $21,600 per year. Both 10 meter and 4.5 meter antenna earth stations are now available from a variety of venders, and "shoping for price" would be possible. The figures quoted do not include the costly and complex engineering task of site clearance (i.e., determining whether interference will be caused or received) or for microwave or other terrestrial end loops in cases in which the earth station must be located at some distance from the user's facilities.

The RCA Satcom space segment costs are approximately as follows: duplex data at 1,544 Mbs, $15,000 per year; 56 Kbs in duplex mode, $4000 per year. The cost for video service runs

$800/hour in prime time, but could fall as low as $150/hour at off hours. A year's lease for a full transponder may be had at $1.4 million. Such service is "fully backed up," that is, service is guaranteed, and the signal is switched to another transponder in case of electronic difficulties and to the other satellite in case of a massive satellite failure.

Comsat General is the operator of yet another existing domestic satellite system. CG's Comstar satellites are modified versions of the Intelsat IV-A's which Hughes built for the International Telecommunications Satellite Consortium. Like RCA's Satcoms, the Comstar satellites use orthogonal polarization to obtain frequency reuse and provide twenty-four, instead of twelve, transponders on each bird.

Although the Comstar satellites (Comstar I is at 128°W and Comstar II is at 95°W) are technically capable of the same full range of voice, data, and television transmissions as the other satellites discussed above, current FCC regulations limit their use to serving the long distance toll telephone message traffic of their sole customers, the American Telephone and Telegraph Co. and General Telephone. AT&T has a seven year lease on the Comstar transponders and the Commission has placed a three year limit on the services which can be offered by satellite, holding AT&T during that period to the toll telephone message service. Later, the telephone company

will be able to use them for such other service offerings as private line and television traffic, and it is hardly unreasonable to assume that the operators will be interested in developing new service offerings for a wide variety of potential customers.

From the viewpoint of a prospective user, the Comstar satellites closely resemble the RCA Satcoms. The use of cross-polarized transponders imposes some additional cost burden on the earth stations, but doubling the number of transponders in space gives the satellites the ability to deliver twice the number of signals, with consequent economies in the cost of transponder time. But, while RCA and Western Union are willing to serve user-owned earth stations, AT&T which will continue to control the Comstar transponders, has long concentrated on end-to-end service and has resisted the use of non-Bell equipment on its terrestrial telephone network.

In short, the Comsat General satellite system, as it presently exists, is thoroughly committed. Comsat General management has, however, suggested that its next generation of satellites is likely be offered to a wider variety of customers and to provide a full panoply of services.

The final FCC authorized commercial domestic satellite system is that owned by Satellite Business Systems, a joint venture of

Comsat General, the International Business Machines Corp., and the Aetna Casualty and Surety Co. Since its founding in 1971 as the MCI Lockheed Satellite Corp., SBS's history has been one of corporate reorganization and regulatory delay. Finally, in 1977, the Federal Communications Commission gave SBS the green light for certain pre-operational tests and for development of its satellite system. No dates have been announced for satellite launches nor for the iniation of regular service, but it is generally believed that SBS cannot possibily be operational much before 1980 at the very earliest.

In concept, technology, and service offerings, SBS is substantially different from the existing commercial domestic satellite systems. Primarily, SBS will offer digital services, including voice and images as well as data, in the form of fully switched private line network configurations. While the other domestic satellites operate in the 4 and 6 GHz bands, SBS will place its service in the newly-available 12 and 14 GHz spectrum which is being pioneered by the US-Canadian experimental Communications Technology Satellite.

By operating in the 12-14 GHz "Ku" band, SBS will eliminate many of the technical problems which force other satellite systems to locate their earth stations (particularly two-way stations) far from the user's premises. Using 5- and 7-meter antennas, SBS plans to locate earth stations on the roof or in the parking lot of each

customer.

SBS plans for its space segment three satellites with a design life of seven years. Two will be in orbit (at 122° and 110°W), one as the primary operational satellite, the other as a secondary operational satellite which will also provide backup to the primary. The third satellite will be an on-ground spare. Each will have eight transponders with a channel bandwidth of 54 MHz and a power of 20 watts. There will be one spare amplifier tube for each pair of transponders to provide built in redundancy in the case of transponder failure. Service will be offered to the contiguous forty-eight states only.

The ground segment will bear a superficial resemblance to the earth stations developed for the experimental CTS, a satellite which can also work into small antenna earth stations. But, because the SBS ground stations will handle digitized signals, and because they will be two-way, their cost will be in the neighborhood of $400,000. Although the SBS system is designed primarily to serve the needs of business and industry users who have a high volume of traffic, small users may be able to have access to the system through ground stations which are shared, rather than located on their permises.

In acting on the SBS application, the Commission determined that

it would not require the carrier to specify rates and tarrifs at this time, but will ask SBS to file such information one year prior to the first scheduled launch date. SBS responded that it will structure its rates to encourage market acceptance, but that its monthly charges will be based upon full recovery of costs, plus a reasonable profit. Potential users in the educational and public service communities will be disappointed to learn that SBS has already announced that it will offer no discounts or preferential rates to educational institutions.

Those interested in the long term development of satellite services for education and in other public service applications need not only to be familiar with the experimental and commercial communications satellites which already exist or are on the drawing boards but also, if their concern is with developing applications which will have viability well into the 1980's and beyond, with what satellite developments are on the horizon and beyond it.

While mere predictions may be of limited value, it is possible to make some reasonable extrapolations from experience to date and already established trends. Further, some plans have already been announced and, while they may be modified by future events, they can provide some insight into what may reasonably be expected.

It is generally agreed that future developments in the field of communications satellites will take increasing advantage of the 11-14 GHz Ku-band. As the experimental CTS demonstrates, it is possible to design satellites of higher power in this band which is unconstrained by regulatory power limitations imposed in the currently used 4-6GHz C-band. As the plans of SBS indicate, a further advantage of these higher and less crowded frequencies is found in the ability of system designers to site earth stations directly on the premises of users. Too, it appears that digital transmission schemes will continue to have an increasing role to play in future systems designs. On the other hand, existing commercial communications satellite operators will not likely abandon the investments already made by themselves and their customers in the 4 and 6 GHz spectrum. Thus, second generation satellite systems of currently operating carriers are likely to be hybrid designs. A case in point is the Advanced Westar system.

Early in 1977, the National Aeronautics and Space Administration announced the award of a $796 million contract to a combine headed by Western Union for a ten year program under which NASA will be provided with service by a Tracking and Data Relay Satellite System which the Western Union group will implement. In essence, Western Union and its partners will, at their own expense, develop and build an advance satellite system against a ten year contract to begin in 1980 under which NASA will pay $79.6 million per year for tracking and data relay services.

Tracking and data relay will receive signals from lower earth orbiting satellites and eliminate the need for a variety of complex and expensive terrestrial tracking stations. The plan put forth by Western Union calls for seven identical satellites, each of which can not only perform the tasks NASA requires, but could also serve as an Advanced Westar for commercial communications purposes.

Four satellites will be placed in orbit; the first two for NASA's use in September 1979 and December of the same year. In the Spring of 1980, the third will be launched as an in-orbit spare which can function either to serve NASA's needs or those of Western Union. About 1982, Western Union will launch the fourth which will function primarily as an Advanced Westar. The remaining spacecraft will be launched as needed. NASA, which will pay no money until service begins in 1980, is funding only the development and operating aspects specifically related to the TDRSS function.

The commercial communications aspects of the satellites will include a 4-foot diameter C-band antenna, similar to those used on the current westars, making the new satellites totally compatible with the existing Westar network. Each satellite will also have a K-band antenna of the same size to be used for future digital communications traffic for commercial purposes. How many channels will be provided in each band, and at what power has not yet been

determined. It can be assumed that the C-band channels will be of approximately the same power as those now available, since the new satellite is being specifically designed to mate with existing terrestrial hardware. The transponders in K-band are likely, for a variety of reasons, to be more powerful, although what impact will be felt in terms of earth station costs is not yet easy to determine.

Additional experimental communications satellites are also in the talking stage. Which, if any, will be developed and eventually launched and available for experimentation will depend upon a variety of considerations, but it is worth noting that there is reason for optimism that ATS-6 and CTS may not be the last of the experimental communications satellites. New experimental satellites not only offer the hope of more opportunities for experimentation, but, because there is increasing attention being given to the complex problems of technology transfer, such satellites may be specifically designed to lead to the development of operational systems tailored to the emerging needs of potential users.

Hughes Aircraft Co. has proposed to the National Aeronautics and Space Administration an enlarged and improved spin-stabilized communications satellite which it calls "Syncom IV," and which it proposes for launch on an early Orbital Flight Test Mission of the

Space Shuttle. The use of Space Shuttle technology offers the opportunity to place in orbit larger satellites at costs substantially lower than are possible with conventional launch methods. It is estimated that, for Syncom IV, use of the Space Shuttle could reduce launch costs by 65%.

Since the NASA Space Shuttle program is seeking pay loads for its early Orbital Flight Tests, the Hughes plan anticipates that the satellite would be launched without additional cost as a part of the OFT program. The benefit to the OFT program would be a dramatic demonstration of the utility of Space Shuttle technology in an area of increasing importance.

For the first time, weight, size and power would no longer be prime constraints in the design of a communications satellite. The final configuration of the communications component of Syncom IV is yet to be established, but from the begining the dialogue has focused upon public service communications development and providing follow-on opportunities for further experimentation based upon the experience gained on ATS-6 and CTS.

The Public Service Satellite Consortium has urged that communications capabilities in both the 2.5 GHz band used by

ATS-6 and the 12 GHz bard which CTS employs should both be included in any Syncom IV communications package. Thus, it is argued, opportunities would be provided for continuation of the type of experiments which have been undertaken by the health and education communities. Further, the investment of public funds already made in earth stations would be protected.

At PSSC's December 1976 Conference on Satellite Communications for Public Service, Hughes representatives presented for discussion purposes a transponder plan which, among other features, would include two channels at 12 GHz for spot beams or time zone coverage; two channels at 2.5 GHz, one of which could provide CONUS (contiguous U.S.) coverage plus Alaska and the second which would serve CONUS and Alaska, plus Hawaii, Puerto Rico, and the Virgin Islands. An additional 12 GHz CONUS channel would be available for low rate packet-switched data. The 12 GHz transponders would operate with 20 watt tubes (comparable to the lesser of the two CTS transponders) and the 2.5 GHz S-band transponders would be at 50 watts, delivering a signal compatible with the existing ATS-6 earth stations. The TV distribution system would employ earth stations with 10 or 12 foot diameter antennas, solid state receivers, and, for those requiring transmit capability, a transmitter in the 500 watt class.

"The transponders linking spot beams or regional zones can be used for data transfer at high data rates," the Hughes description explains,

"as might be appropriate for library document retrieval, computer based instruction, etc. Another service being postulated by PSSC involves data transfer at low rates (300 bauds) locally and "burst" transmission over the satellite link at 4800 bps (still a modest rate) amongst a large number of users (5000 to 10,000). The system would operate at Ku band through the CONUS coverage repeater."

The launch of Syncom IV, if approved by NASA for an early Orbital Flight Test mission of the Space Shuttle, could come in 1979. The timing would bear an important relationship with another proposed experimental communications satellite program being explored by NASA's Goddard Space Flight Center.

Noting that a new research and development effort in communications satellite technology for NASA would be consistent the independent recommendations of the National Research Council, the American Institute of Aeronautics and Astronautics, and the Institute of Electrical and Electronics Engineers, the Goddard study observes that "the major obstacle to date to the increased use of satellites for communications services other than long distance telephone is not the lack of available technology, but the absence of well-developed institutional arrangements and the lack of appreciation of the services that can be provided by satellites and their potential both for cost effectiveness and increasing the quality of life." ["Public Services Communications

System," dtd Oct 1976, distributed at the Public Service Communications Satellite User Requirements Workshop, Easton, Md.]

From deliberations with potential users and examination of the technology options available, the Goddard project staff has evolved a tentative spacecraft design and planned proceedures. As currently seen by the Goddard staff, a Public Service Communications Satellite might include simultaneous coverage of the United States by means of four regional beams for the continental US, plus spot beams for Alaska, Hawaii and Puerto Rico. Each would use a 100 watt transmitter at 12 GHz, and would be capable of working into earth stations with 1.8 meter antennas. The spot beams would be powered at 30 watts. Transmitting ground stations would use 300 watts of power for video signals or 10 watt transmitters for audio.

It should be noted that such a design is, at this time, only a model for discussion. The interest of some users in 2.5 GHz capability is not addressed in this model, and the Goddard staff is giving this matter further consideration. If such a program is submitted by NASA as a part of its 1979 budget, such a satellite could not possibly be launched until 1982. Any advanced version of the prospective Public Service Communications Satellite would have to follow by several years.

While NASA's reentry into the research and development area of

communications satellites is far from a foregone conclusion, the most prompt and timely affirmative action would still leave a vital gap between the anticipated expiration of ATS-6 and CTS and the birth of a new Public Service Communications Satellite.

Thus a decision concerning the Hughes proposal for the development of Syncom IV and its 1979 launch on the Space Shuttle becomes a matter of critical importance. Should NASA chose to move ahead on the Goddard proposal, an affirmative decision in regard to Syncom IV is a virtual necessity, lest the momentum developed in the public service and technology communities by the availability of ATS-6 and CTS be forfited. Even a "maybe" in regard to PSCS development makes a strong argument for approval of Syncom IV and for concern by NASA with the communications options which the Hughes satellite should offer.

Conclusions:

Opportunities for experimentation exist on both NASA experimental and commercial, operational satellites. In future, such options may be further increased by the development of new satellites in both the private and public sector.

The costs of earth stations are not clearly defined, and differences in frequency and modulation schemes appear to have

less impact on earth station costs than does technical complexity. At all bands of interest the most significant cost variable is quantity, the degree to which large scale production will be employed and the substantial benefits of economies of scale realized.

Those taking the long view, interested in satellite experiments which, while they might begin on NASA satellites would eventually mature into larger, independentently viable projects with a continuing life, need not limit their forward planning to those commercial communications satellite systems which are already in place. It appears clear that one of the most significant implications of the National Institute of Education's funding of satellite experiments may be the impetus such activities give to the definition and demonstration of long term needs and the influence that process will have on the design and development of future satellite systems.

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Burke, J. Russell and Frank W. Norwood, "Satellite Developments and the ATS-6," Audiovisual Instruction, May 1975, 12-16.

"Commercial Satellite Usage Enters Second Decade in 1975," Communication News, Feb 1975, 28-29.

"Domestic Satellite System Benefits 'Have Just Begun'," Com News, Feb 1977, 48-49.

"FCC Approves Use of Smaller Domsat Antennas," Com News, Feb 1977, 10.

Grayson, Lawrence P., Frank W. Norwood and Harold E. Wigren, Man-Made Moons: Satellite Communications for Schools, Washington: National Education Association, 1972.

Polcyn, Kenneth A., An Educator's Guide to Communication Satellite Technology, Washington: Andromeda Books, 1973.

"Satellites Open Up the World of Reliable, Low-Cost Communications," Com News, Feb 1975, 26-27.

Norwood, Frank W., "The Next Ten Years in Satellite Development," in John P. Witherspoon, ed., State of the Art, Washington: Advisory Council of National Organizations, Corporation for Public Broadcasting, 1974.

_____"The satellite technology demonstration and health-education telecommunications experiments on ATS-6," Proceedings of the Royal Society, London, A. 345, 541-557, (1975).

_____"Satellites and Education--The Development of Experiments on NASA Satellites," a paper for the Instituto Latinoamericano de Comunicaciones Educativas (ILCE-UNESCO), Mexico City, Oct 14, 1975.

Wheelon, Albert D., "How Worldwide Communication Satellite Services Will Expand in the Next Decade," Com News, Jan 1976, 16-19.

American Satellite Corporation:

"American Satellite redirects domsat program, plans to lease transponders from WU in first phase of operation," Telecommunication Reports, Feb 25, 1974, 3-4.

"American Satellite Builds Vast Government Satellite Network," Com News, Feb 1975, 32-33.

"ASC gets FCC approval for domestic satellite system," Telecommunication Reports, Mar 31, 1975, 38.

"Bank of America Uses New American Satellite Earth Station," Com News, May 1976, 84.

"American Satellite Provides End-to-End Service Options," Com News, Feb 1977, 54.

"Dow Jones Ups Satellite Usage," Com News, Mar 1977, 15.

Comstar (Comsat General):

"AT&T, GSAT propose joint domestic satellite system. . . .," Telecommunication Reports, Apr 22, 1974, 1-3.

"AT&T, GSAT plan start of domsat operations in mid-1976," Telecommunication Reports, Dec 22, 1975, 20-21.

"FCC Okays AT&T-GTE Joint Satcom System," Com News, Jan 1976, 10.

"First Comstar Launched by AT&T and GSAT," Com News, June 1976, 1.

"Comstar Begins Domsetic LD, WATS Service," Com News, Sep 1976, 2.

"AT&T/GTE Comstar System Routes Long Distance Traffic," Com News, Feb 1977, 55.

Anik (Telesat Canada):

"Telesat Canada's Anik I now in synchronous orbit," Telecom Rpts, Nov 20, 1972, 13.

"Amendment to Telesat Canada's charter would allow service to points outside Canada. . . .," Telecom Rpts, Nov 27, 1972, 17-18.

"RCA companies file for 'interim' system using Telesat," Telecom Rpts, Mar 19, 1973, 12-13.

"Temporary use of Telesat Canada's Anik system by U.S. firms in public interest, FCC rules in approving ASC application," Telecom Rpts, Apr 23, 1973, 1-2.

"RCA gets Telesat Canada contract for domestic satellite," Telecom Rpts, Dec 15, 1975, 18-19.

Thorpe, D. G., "Evolution of the Telesat Canada System into the Mid 1980's," a paper presented at the AIAA/CASI Sixth Communications Satellite Systems Conference, Montreal, Apr 5-8, 1976.

Satcom (RCA):

"RCA companies file for 'interim' system using Telesat," Telecom Rpts, Mar 19, 1973, 12-13.

"RCA companies inaugurate first U.S. domestic satellite net," Telecom Rpts, Jan 14, 1974, 9.

"Satcom Bridges Continent with Commercial Satellite Services," Com News, Feb 1975, 30-31.

"RCA decides to go ahead with domestic satellite launch," Telecom Rpts, Dec 15, 1975, 18.

"RCA Satcom 1 Now in Orbit at 119° West Longitude," Com News, Jan 1976, 38-41.

"RCA Satcom II Doubles RCA Channel Capacity in Space," Com News, May 1976, 24-25.

"RCA Alascom Uses Satellites and Microwave to Serve 'Frontier'," Com News, May 1976, 32-34.

"Innovative Tariffs and Service Offerings Seen as Keys to Success in Domestic Satellite Arena," (interview with Phillip Schneider, president of RCA Americom), Com News, May 1976, 26-27.

"RCA Satcom System Offers Voice, Video, Data Services," Com News, Feb 1977, 50-51.

"Alaska Bush TV Coverage Begins for 23 Communities," Com News, Mar 1977, 18.

"Hughes Network Increasing Use of RCA Satcom," Com News, Mar 1977, 8.

SBS (Satellite Business Systems):

"Comsat General, IBM and Aetna detail new venture to be known as Satellite Business Systems in FCC filing," Telecom Rpts, Jan 5, 1976, 4-8.

Kittiver, C. and F. R. Zitzmann, "The SBS System--an Innovative Domestic Satellite System for Private-Line Networks," a paper presented at the AIAA/CASI Sixth Communication Satellite Systems Conference, Montreal, Apr 5, 1976.

"Satellite Business Systems plan for all-digital domsat net. . . .," Telecom Rpts, Jan 24, 1977, 1-4.

"Satellite Business System to Begin Operating," NY Times, Jan 19, 1977, D-1.

"SBS System Approved for First Phases," Com News, Mar 1977, 1.

"ComQuest Study of SBS System," Com News, Mar 1977, 9.

Syncom IV (Hughes Aircraft Co.)

"Syncom IV," Hughes Aircraft Corp., Dec 1976 (Hughes Ref. No. 76(44)-23956/D9393 SCG 6049P).

Jones, C. Richard, "Syncom IV Space Shuttle Orbital Flight Test Mission," a paper presented at the Public Service Satellite Consortium Conference, Washington, Dec 1976.

Westar (Western Union):

"Western Union, aiming to be first with domestic satellite system, awards contract to Hughes for three spacecraft," Telecom Rpts, Aug 14, 1972, 1-2.

"Western Union to launch Westar in ceremonies," Telecom Rpts, July 15, 1974, 17.

"WU launches domsat service via Westar I. . . .," Telecom Rpts, July 22, 1974, 11-13.

"Westar Domestic Satellite Provides New Answers for Private Telephone Networks," Com News, Feb 1975, 36-37.

"Telepost Provides New Way to Send Mailgrams via Western Union's Westar Domestic Satellite," Com News, Feb 1975, 46.

"WU reports plans to launch domsat TV transmission service," Telecom Rpts, June 23, 1975, 11-12.

"TDRSS Won by Western Union," Aviation Week & Space Technology, Jan 3, 1977, 14-16.

"Western Union to Supply New Satellite System for NASA," Com News, Feb 1977, 6.

"Western Union Spans Country with Wire, Westar Satellites," Com News, Feb 1977, 52-53.

"Bids on Public Radio Satellite Interconnection," Com News, Mar 1977, 12.

Wiley, Don, "From Wire to Westar: Western Union's Changing Image," Com News, Mar 1977, 39-45.